



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Refer to:
2003/00412

August 18, 2003

Mr. Lawrence Evans
U.S. Army Corps of Engineers, Portland District
ATTN: John Barco
P.O. Box 2946
Portland, OR 97208-2946

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on an Irrigation Pump Float for Robert Light, River Mile 35.4, Willamette River, Clackamas County, Oregon (Corps. No. 200300114)

Dear Mr. Evans:

Enclosed is a biological opinion (Opinion) prepared by NOAA's National Marine Fisheries Service (NOAA Fisheries) pursuant to section 7 of the Endangered Species Act (ESA) on the effects of issuing a permit for construction of an irrigation pump float for Robert Light, on the Willamette River at mile 35.4, Multnomah County, Oregon. NOAA Fisheries concludes in this Opinion that the proposed action is not likely to jeopardize the continued existence of Upper Willamette River (UWR) chinook (*Oncorhynchus tshawytscha*) or UWR steelhead (*O. mykiss*). As required by section 7 of the ESA, we include reasonable and prudent measures with non-discretionary terms and conditions that are necessary to minimize the potential for incidental take associated with this action.

This Opinion also serves as consultation on essential fish habitat (EFH) for chinook salmon (*O. tshawytscha*) and coho salmon (*O. kisutch*) pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation Management Act and its implementing regulations at 50 CFR Part 600.

Please direct any questions regarding this consultation to Christy Fellas of my staff in the Oregon Habitat Branch at 503.231.2307.

Sincerely,

f.1 Michael R. Crouse

D. Robert Lohn
Regional Administrator



Endangered Species Act - Section 7 Consultation Biological Opinion

&


Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

Irrigation Pump Float for Robert Light
River Mile 35.4, Willamette River
Clackamas County, Oregon.
(Corps No. 200300114)

Agency: U.S. Army Corps of Engineers

Consultation
Conducted By: NOAA's National Marine Fisheries Service,
Northwest Region

Date Issued: August 18, 2003

Issued by: 

D. Robert Lohn
Regional Administrator

Refer to: 2003/00412

TABLE OF CONTENTS

1. INTRODUCTION	<u>1</u>
1.1 Background	<u>1</u>
1.2 Proposed Action	<u>1</u>
2. ENDANGERED SPECIES ACT	<u>2</u>
2.1 Biological Opinion	<u>2</u>
2.1.1 Biological Information	<u>2</u>
2.1.2 Evaluating Proposed Action	<u>3</u>
2.1.3 Biological Requirements	<u>4</u>
2.1.4 Environmental Baseline	<u>4</u>
2.1.5 Analysis of Effects	<u>5</u>
2.1.5.1 Direct Effects of the Proposed Action	<u>5</u>
2.1.5.2 Interrelated and Interdependent Effects of the Proposed Action	<u>7</u>
2.1.5.3 Cumulative Effects	<u>8</u>
2.1.6 Conclusion	<u>8</u>
2.1.7 Reinitiation of Consultation	<u>8</u>
2.2 Incidental Take Statement	<u>9</u>
2.2.1 Amount or Extent of the Take	<u>9</u>
2.2.2 Reasonable and Prudent Measures	<u>9</u>
2.2.3 Terms and Conditions	<u>10</u>
3. MAGNUSON-STEVENSON ACT	<u>14</u>
3.1 Magnuson-Stevens Fishery Management and Conservation Act	<u>14</u>
3.2 Identification of EFH	<u>15</u>
3.3 Proposed Action	<u>16</u>
3.4 Effects of Proposed Action	<u>16</u>
3.5 Conclusion	<u>16</u>
3.6 EFH Conservation Recommendations	<u>16</u>
3.7 Statutory Response Requirement	<u>16</u>
3.8 Supplemental Consultation	<u>17</u>
4. LITERATURE CITED	<u>18</u>

1. INTRODUCTION

1.1 Background

On April 14, 2003, NOAA's National Marine Fisheries Service (NOAA Fisheries) received a letter from the U.S. Army Corps of Engineers (Corps) requesting informal consultation pursuant to the Endangered Species Act (ESA) for the issuance of a permit under section 10 of the Rivers and Harbors Act to Robert Light for the construction of an irrigation pump float at river mile 35.4 of the Willamette River, in Clackamas County, Oregon. The Corps determined the proposed action was not likely to adversely affect ESA-listed Upper Willamette River (UWR) chinook (*Oncorhynchus tshawytscha*) or UWR steelhead (*O. mykiss*). On April 28, 2003, NOAA Fisheries sent a letter to the Corps explaining that the action was likely to adversely effect listed species and that enough project information was received to complete consultation within 135 days.

Species' information references, listing dates and take prohibitions are listed in Table 1. The objective of this Opinion is to determine whether the proposed action is likely to jeopardize the continued existence of the ESA listed species for these species. This consultation is conducted pursuant to section 7(a)(2) of the ESA and its implementing regulations, 50 CFR 402.

Table 1. References for Additional Background on Listing Status, Biological Information, and Protective Regulations for the ESA-Listed Species Considered in this Opinion.

Species / ESU	Status	Protective Regulations	Biological Information
Chinook salmon (<i>O. tshawytscha</i>)			
Upper Willamette River	Threatened 3/24/00; 64 FR 14308	7/10/00; 65 FR 42422	Myers <i>et al.</i> 1998; Healey 1991
Steelhead (<i>O. mykiss</i>)			
Upper Willamette River	Threatened 3/25/99; 64 FR 14517	7/10/00; 65 FR 42422	Busby et al. 1995; 1996

1.2 Proposed Action

Currently, the applicant has a pump house at the top of the slope with a 26-inch-wide track to transport the submersible pump down to an existing float made of barrels. The proposed action is the construction of an irrigation pump float on the Willamette River. The float will be 20 by 20 feet, constructed of wood and encapsulated polystyrene floats. Untreated wood on the deck will be spaced with 1.5-foot open spaces to allow light penetration under the float. Two 12-inch steel piles will be driven below ordinary high water (OHW). The pump will be fitted with a pre-

fabricated, self-cleaning screen in compliance with NOAA Fisheries' criteria. All construction will take place during the in-water work window of June 1 - October 31 or December 1 - January 31.

2. ENDANGERED SPECIES ACT

2.1 Biological Opinion

2.1.1 Biological Information

The action area is defined by NOAA Fisheries regulations (50 CFR 402) as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area is the Willamette River including the streambed, streambank, water column and adjacent riparian zone at River Mile 35.4 and 300 feet upstream and 300 feet downstream of the construction area.

Essential habitat features for salmonids are: Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (juvenile only), riparian vegetation, space, and safe passage conditions. The proposed action may affect the essential habitat features of cover/shelter, safe passage and water quality as it pertains to rearing and migration of juveniles. The Willamette River within the action area serves as a rearing and migration area for listed salmonids.

According to a recent draft of "Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead," drafted by the West Coast Salmon Biological Review Team (BRT), a number of ESUs were concluded by the majority of the BRT "likely to become endangered in the foreseeable future:" including: Upper Willamette River chinook, and Upper Willamette River steelhead (NMFS 2003). Preliminary conclusions for each listed ESU considered in this Opinion are discussed below.

Upper Willamette River Chinook

All spring chinook in the ESU, except those entering the Clackamas River, must pass Willamette Falls. There is no assessment of the ratio of hatchery-origin to wild-origin chinook passing the falls, but the majority of fish are undoubtedly of hatchery origin. (Natural-origin fish are defined as having had parents that spawned in the wild as opposed to hatchery-origin fish whose parents spawned in a hatchery). Individual populations' status is discussed below. No formal trend analyses were conducted on any of the UW chinook populations. The two populations with long time series of abundance (Clackamas and McKenzie) have insufficient information on the fraction of hatchery-origin spawners to permit a meaningful analysis.

An analysis was conducted by Steel and Sheer (2002) to assess the number of stream miles historically and currently available to salmon populations in the Upper Willamette. Stream miles usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream miles, as it

does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat miles currently accessible is significantly reduced from the historical condition.

A large number of spring chinook are released in the Upper Willamette River as mitigation for the loss of habitat above Federal hydroprojects. This hatchery production is considered a potential risk, because it masks the productivity of natural population, interbreed of hatchery and natural fish poses potential genetic risks and the incidental take from the fishery promoted by the hatchery production can increase adult mortality. Harvest retention is only allowed for hatchery marked fish, but take from hooking mortality and non-compliance is still a potential issue.

Upper Willamette River Steelhead

All steelhead in this ESU must pass Willamette Falls. Two groups of winter steelhead currently exist in the Upper Willamette River. The “late-run” winter steelhead exhibit the historical phenotype adapted to passing the seasonal barrier at Willamette Falls. The falls were laddered and hatchery “early-run” winter steelhead fish were released above the falls. The early-run fish were derived from Columbia Basin steelhead outside the Willamette River and are considered non-native. The release of winter-run hatchery steelhead has recently been discontinued, but some early-run winter steelhead are still returning from the earlier hatchery releases and from whatever natural production of the early-run fish that has been established. Non-native summer run hatchery steelhead are also released into the Upper Willamette River. There are currently no estimates of the absolute total numbers of spawners in the individual populations.

As in the LCR steelhead ESU, the BRT could not conclusively identify a single population that is naturally self-sustaining. All populations are relatively small, with the recent mean abundance of the entire ESU at less than 6,000. Over the period of the available time series, most of the populations are in decline. The recent elimination of the winter-run hatchery production will allow estimation of the naturally productivity of the populations in the future, but the available time series are confounded by the presence of hatchery-origin spawners. On a positive note, the counts all indicate an increase in abundance in 2001, likely at least partly as a result of improved marine conditions.

2.1.2 Evaluating Proposed Actions

The standards for determining jeopardy are set forth in section 7(a)(2) of the ESA as defined by 50 CFR Part 402. NOAA Fisheries must determine whether the action is likely to jeopardize the listed species and/or whether the action is likely to destroy or adversely modify critical habitat. This analysis involves the initial steps of: (1) Defining the biological requirements and current status of the listed species; and (2) evaluating the relevance of the environmental baseline to the species’ current status.

Subsequently, NOAA Fisheries evaluates whether the action is likely to jeopardize the listed species by determining if the species can be expected to survive with an adequate potential for recovery. In making this determination, NOAA Fisheries must consider the estimated level of

mortality attributable to: (1) Collective effects of the proposed or continuing action; (2) the environmental baseline; and (3) any cumulative effects. If NOAA Fisheries finds that the action is likely to jeopardize the listed species, NOAA Fisheries must identify reasonable and prudent alternatives for the action.

For the proposed action, NOAA Fisheries' jeopardy analysis considers direct or indirect mortality of fish attributable to the action. NOAA Fisheries' analysis considers the extent to which the proposed action impairs the function of essential elements necessary for migration, spawning, and rearing of listed species under the existing environmental baseline.

2.1.3 Biological Requirements

The first step in the methods NOAA Fisheries uses for applying the ESA section 7(a)(2) to listed salmonids is to define the species' biological requirements that are most relevant to each consultation. NOAA Fisheries also considers the current status of the listed species, taking into account population size, trends, distribution and genetic diversity. To assess the current status of the listed species, NOAA Fisheries starts with the determinations made in its decision to list the species for ESA protection and also considers new data available that is relevant to the determination.

The relevant biological requirements are those necessary for the listed species to survive and recover to a naturally-reproducing population level, at which time protection under the ESA would become unnecessary. Adequate population levels must safeguard the genetic diversity of the listed stock, enhance its capacity to adapt to various environmental conditions, and allow it to become self-sustaining in the natural environment.

For this consultation, the biological requirements are improved habitat characteristics that function to support successful rearing and migration. The current status of the listed species, based upon their risk of extinction, has not significantly improved since the species were listed.

2.1.4 Environmental Baseline

The Willamette River watershed covers a vast area (29,785 square kilometers) bordered on the east and west by the Cascades and the Pacific coast ranges. It drains from as far south as Cottage Grove and flows north to its confluence with the Columbia River. The Willamette River watershed is the largest river basin in Oregon. It is home to most of the state's population, its largest cities, and many major industries. The watershed also contains some of Oregon's most productive agricultural lands and supports important fishery resources (City of Portland 2001).

The uplands (Coast and Cascade Ranges) receive about 80% of the precipitation falling on the Willamette River basin, and store much of this water as snow. Ecosystem productivity in these upland streams is relatively low, with aquatic insects gleaning much of their diet from material that falls into running water. In larger, slower tributaries, more plant material is produced in the stream itself. The mainstem supports a highly productive algal community that blooms as

temperatures rise in the summer. Insects and some vertebrates feed on these plants, and many vertebrates, including salmonids, feed on stream-dwelling insects. Much of the habitat for Willamette River salmonids has been degraded by various land use practices or eliminated by dams. Wild salmonid populations have declined precipitously over the last century in the Willamette River (WRI 1999).

Significant changes have occurred in the watershed since the arrival of Europeans in the 1800s. The watershed was mostly forested land before the arrival of white settlers. Now, about half the basin is still forested. One-third of the basin is used for agriculture, and about 5% is urbanized or is in residential use. The river receives direct inputs from treated municipal wastes and industrial effluents. Non-point-source input from agricultural, silvicultural, residential, urban and industrial land uses are also significant, especially during rainfall runoff.

2.1.5 Analysis of Effects

2.1.5.1 Direct Effects of the Proposed Action

Predator species such as northern pikeminnow (*Ptychocheilus oregonensis*), and introduced predators such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), black crappie (*Pomoxis nigromaculatus*) white crappie (*P. annularis*) and, potentially, walleye (*Stizostedion vitreum*) (Ward *et al.* 1994, Poe *et al.* 1991, Beamesderfer and Rieman 1991, Rieman and Beamesderfer 1991, Petersen *et al.* 1990, Pflug and Pauley 1984, and Collis *et al.* 1995) may utilize habitat created by over-water structures (Ward and Nigro 1992, Pflug and Pauley 1984) such as piers, float houses, floats and docks (Phillips 1990). However, the extent of increase in predation on salmonids in the lower Columbia River resulting from over-water structures is not well known.

Major habitat types utilized by largemouth bass include vegetated areas, open water and areas with cover such as docks and submerged trees (Mesing and Wicker 1986). During the summer, bass prefer pilings, rock formations, areas beneath moored boats, and alongside docks. Colle *et al.* (1989) found that, in lakes lacking vegetation, largemouth bass distinctly preferred habitat associated with piers, a situation analogous to the Columbia River. Marinas also provide wintering habitat for largemouth bass out of mainstem current velocities (Raibley *et al.* 1997). Bevelhimer (1996), in studies on smallmouth bass, indicates that ambush cover and low light intensities create a predation advantage for predators and can also increase foraging efficiency. Wanjala *et al.* (1986) found that adult largemouth bass in a lake were generally found near submerged structures suitable for ambush feeding.

There are four major predatory strategies utilized by piscivorous fish. They: (1) Run down prey; (2) ambush prey; (3) habituate prey to a non-aggressive illusion; or (4) stalk prey (Hobson 1979). Ambush predation is probably the most common strategy; predators lie in wait, then dart out at the prey in an explosive rush (Gerking 1994). Predators may use sheltered areas that provide slack water to ambush prey fish in faster currents (Bell 1991).

Light plays an important role in defense from predation. Prey species are better able to see predators under high light intensity, thus providing the prey species with an advantage (Hobson 1979, Helfman 1981). Petersen and Gadomski (1994) found that predator success was higher at lower light intensities. Prey fish lose their ability to school at low light intensities, making them vulnerable to predation (Petersen and Gadomski 1994). Howick and O'Brien (1983) found that in high light intensities prey species (bluegill) can locate largemouth bass before they are seen by the bass. However, in low light intensities, the bass can locate the prey before they are seen. Walters *et al.* (1991) indicate that high light intensities may result in increased use of shade-producing structures. Helfman (1981) found that shade, in conjunction with water clarity, sunlight and vision, is a factor in attraction of temperate lake fishes to overhead structure.

An effect of over-water structures is the creation of a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. The incorporation of grating into all of the docks allows for more light penetration and diffuses the light/dark interface. This will minimize the susceptibility of juvenile salmonids to piscivorous predation resulting from this project.

In addition to piscivorous predation, in-water structures (tops of pilings) also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*), from which they can launch feeding forays or dry plumage. Their high energy demands associated with flying and swimming create a need for voracious predation on live prey (Ainley 1984). Cormorants are underwater pursuit swimmers (Harrison 1983) that typically feed on mid-water schooling fish (Ainley 1984), but they are known to be highly opportunistic feeders (Derby and Lovvorn 1997; Blackwell *et al.* 1997; Duffy 1995). Double-crested cormorants are known to fish cooperatively in shallow water areas, herding fish before them (Ainley 1984). Krohn *et al.* (1995) indicate that cormorants can reduce fish populations in forage areas, thus possibly affecting adult returns as a result of smolt consumption. Because their plumage becomes wet when diving, cormorants spend considerable time drying out feathers (Harrison 1983) on pilings and other structures near feeding grounds (Harrison 1984). Placement of piles to support the dock structures will potentially provide for some usage by cormorants. Placement of anti-perching devices on the top of the pilings would preclude their use by any potential avian predators.

The proposed project has incorporated anti-perching devices on the tops of pilings. Spacing between the wood on the deck area of the float to allow light penetration will provide cover for listed fish and reduce the likelihood of predatory fishes using ambush strategies.

Pile driving often generates intense sound pressure waves that can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). The type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer all influence the sounds produced during pile driving. Sound pressure is positively correlated with the size of the

pile because more energy is required to drive larger piles. Wood and concrete piles produce lower sound pressures than hollow steel piles of a similar size, and may be less harmful to fishes. Firmer substrates require more energy to drive piles and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988). Impact hammers produce intense, sharp spikes of sound that can easily reach levels that harm fishes, and the larger hammers produce more intense sounds. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate.

Fish respond differently to sounds produced by impact hammers than they do to sounds produced by vibratory hammers. Fish consistently avoid sounds like those of a vibratory hammer (Enger *et al.* 1993; Dolat 1997; Knudsen *et al.* 1997; Sand *et al.* 2000) and appear not to habituate to these sounds, even after repeated exposure (Dolat, 1997; Knudsen *et al.* 1997). On the other hand, fish may respond to the first few strikes of an impact hammer with a ‘startle’ response, but then the startle response wanes and some fish remain within the potentially-harmful area (Dolat 1997). Compared to impact hammers, vibratory hammers make sounds that have a longer duration (minutes vs. milliseconds) and have more energy in the lower frequencies (15-26 Hz vs. 100-800 Hz) (Würsig, *et al.* 2000; Carlson *et al.* 2001; Nedwell and Edwards 2002).

Water quality may be affected during construction, while piles are being driven. Increased turbidity is likely during pile driving, but it is expected to be short-term and minor in scale. Using a vibratory hammer to drive the two piles will reduce the impacts to listed species from sound pressure waves.

The effect of screening the existing irrigation intake is wholly beneficial for listed species. The intake will be screened according to NOAA Fisheries’ intake criteria. Properly screened intakes prevent mortality of juveniles caused by the velocity or suction against the screen.

2.1.5.2 Interrelated and Interdependent Effects of the Proposed Action

Interrelated and interdependent actions of the proposed action include the changes in water quantity in the Willamette River due to effects of withdrawing water for irrigation. Currently, the Willamette River is one of the few waterways in Oregon that does not have allocated water rights that exceed the amount of water available. The proposed withdrawal of 0.28 cfs is not likely to have a measurable impact on water quantity in the lower Willamette.

2.1.5.3 Cumulative Effects

Cumulative effects are defined in 50 CFR 402.02 as those effects of “future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation.” Future Federal actions, including the ongoing operation of hydropower systems, hatcheries, fisheries, and land management activities are being (or have been) reviewed through separate section 7 consultation processes. Therefore, these actions are not considered cumulative to the proposed action.

NOAA Fisheries is not aware of any specific future non-federal activities within the action area that would cause greater impacts to listed species than presently occurs. NOAA Fisheries assumes that future private and state actions will continue at similar intensities as in recent years.

2.1.6 Conclusion

NOAA Fisheries has determined that, based on the available information, the proposed action is not likely to jeopardize the continued existence of listed species. NOAA Fisheries used the best available scientific and commercial data to analyze the effects of the proposed action on the biological requirements of the species relative to the environmental baseline, together with cumulative effects. NOAA Fisheries believes that the proposed action will cause a minor, short-term degradation of anadromous salmonid habitat due to increased turbidity and sound effect from pile driving. Direct mortality is not expected.

These conclusions are based on the following considerations: (1) Construction will take place during the preferred in-water work windows of June 1 - October 31 and December 1 - January 31; (2) any increases in sedimentation and turbidity in the project area will be short-term and minor in scale, and would not change or worsen existing conditions for stream substrate in the action area; (3) best management practices will be followed to avoid or minimize the adverse effects of all construction activities; (4) the existing pump will be fitted with a fish screen to meet NOAA Fisheries' criteria; and (5) the proposed action is not likely to impair properly functioning habitat, or retard the long-term progress of impaired habitat toward proper functioning condition essential to the long-term survival and recovery at the population or ESU scale.

2.1.7 Reinitiation of Consultation

Consultation must be reinitiated if: (1) The amount or extent of taking specified in the incidental take statement is exceeded, or is expected to be exceeded; (2) new information reveals effects of the action may affect listed species in a way not previously considered; (3) the action is modified in a way that causes an effect on listed species that was not previously considered; or (4) a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16).

2.2 Incidental Take Statement

The ESA at section 9 [16 USC 1538] prohibits take of endangered species. The prohibition of take is extended to threatened anadromous salmonids by section 4(d) rule [50 CFR 223.203]. Take is defined by the statute as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." [16 USC 1532(19)] Harm is defined by regulation as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavior patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering." [50 CFR 222.102] Harass is defined as "an intentional or

negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.” [50 CFR 17.3] Incidental take is defined as “takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant.” [50 CFR 402.02] The ESA at section 7(o)(2) removes the prohibition from any incidental taking that is in compliance with the terms and conditions specified in a section 7(b)(4) incidental take statement [16 USC 1536].

2.2.1 Amount or Extent of the Take

NOAA Fisheries anticipates that the action covered by this Opinion is reasonably certain to result in incidental take of listed species. Effects of actions such as these are largely unquantifiable and are not expected to be measurable as long-term effects on population levels. Therefore, even though NOAA Fisheries expects some low level incidental take to occur due to the actions covered by this Opinion, the best scientific and commercial data available are not sufficient to enable NOAA Fisheries to estimate a specific amount of incidental take to the species itself. In instances such as these, NOAA Fisheries designates the expected level of take as "unquantifiable". Based on the information provided by the Corps, NOAA Fisheries anticipates that an unquantifiable amount of incidental take could occur as a result of the actions covered by this Opinion.

The extent of the take is limited to disturbance resulting from construction activities within the action area.

2.2.2 Reasonable and Prudent Measures

The measures described below are non-discretionary. They must be implemented so that they become binding conditions in order for the exemption in section 7(a)(2) to apply. The Corps has the continuing duty to regulate the activities covered in this incidental take statement. If the Corps fails to require the applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, or fails to retain the oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

NOAA Fisheries believes that, in addition to the conditions proposed by the Corps, the following reasonable and prudent measures are necessary and appropriate to minimize the likelihood of take of listed fish resulting from implementation of this Opinion. These reasonable and prudent measures would also minimize adverse effects to designated critical habitat.

The Corps shall include measures that will:

1. Minimize incidental take from general construction by applying permit conditions that avoid or minimize adverse effects to riparian and aquatic systems.

2. Complete a comprehensive monitoring and reporting program to ensure implementation of these conservation measures are effective at minimizing the likelihood of take from permitted activities.

2.2.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures described above for each category of activity.

1. To implement reasonable and prudent measure #1 (general conditions for construction, operation and maintenance), the Corps shall apply the following conditions to this permit:
 - a. Minimum area. Confine construction impacts to the minimum area necessary to complete the project.
 - b. Timing of in-water work. Work below the bankfull elevation¹ will be completed during the preferred in-water work period of June 1 - October 31, and December 1 - January 31, unless otherwise approved in writing by NOAA Fisheries.
 - c. Fish screens. Have a fish screen installed, operated and maintained according to NOAA Fisheries' fish screen criteria² on each water intake used for project construction, including pumps used to isolate an in-water work area. Screens for water diversions or intakes that will be used for irrigation, municipal or industrial purposes, or any use besides project construction are not authorized.
 - d. Pollution and Erosion Control Plan. Prepare and carry out a pollution and erosion control plan to prevent pollution caused by surveying or construction operations. The plan must be available for inspection on request by Corps or NOAA Fisheries.
 - i. Plan Contents. The pollution and erosion control plan will contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.
 - (1) The name and address of the party(s) responsible for accomplishment of the pollution and erosion control plan.
 - (2) Practices to prevent erosion and sedimentation associated with access roads, stream crossings, drilling sites, construction sites, borrow pit operations, haul roads, equipment and material storage

¹ 'Bankfull elevation' means the bank height inundated by a 1.5 to 2-year average recurrence interval and may be estimated by morphological features such average bank height, scour lines and vegetation limits.

² National Marine Fisheries Service, *Juvenile Fish Screen Criteria* (revised February 16, 1995) and *Addendum: Juvenile Fish Screen Criteria for Pump Intakes* (May 9, 1996) (guidelines and criteria for migrant fish passage facilities, and new pump intakes and existing inadequate pump intake screens) (<http://www.nwr.noaa.gov/1hydroweb/hydroweb/ferc.htm>).

- sites, fueling operations, staging areas, and roads being decommissioned.
- (3) Practices to confine, remove and dispose of excess concrete, cement, grout, and other mortars or bonding agents, including measures for washout facilities.
 - (4) A description of any regulated or hazardous products or materials that will be used for the project, including procedures for inventory, storage, handling, and monitoring.
 - (5) A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.
 - (6) Practices to prevent construction debris from dropping into any stream or waterbody, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.
- ii. Inspection of erosion controls. During construction, monitor instream turbidity and inspect all erosion controls daily during the rainy season and weekly during the dry season, or more often as necessary, to ensure the erosion controls are working adequately.³
 - (1) If monitoring or inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs, install replacements, or install additional controls as necessary.
 - (2) Remove sediment from erosion controls once it has reached 1/3 of the exposed height of the control.
- e. Piling installation. Install temporary and permanent pilings as follows.
 - i. Minimize the number and diameter of pilings, as appropriate, without reducing structural integrity.
 - ii. Drive each piling as follows to minimize the use of force and resulting sound pressure.
 - (1) Hollow steel pilings greater than 24 inches in diameter, and H-piles larger than designation HP24, are not authorized under this Opinion.
 - (2) When impact drivers will be used to install a pile, use the smallest driver and the minimum force necessary to complete the job. Use a drop hammer or a hydraulic impact hammer, whenever feasible and set the drop height to the minimum necessary to drive the piling.

³ 'Working adequately' means that project activities do not increase ambient stream turbidity by more than 10% above background 100 feet below the discharge, when measured relative to a control point immediately upstream of the turbidity causing activity.

- (3) When using an impact hammer to drive or proof steel piles, one of the following sound attenuation devices will be used to reduce sound pressure levels by 20 decibels.
 - (a) Place a block of wood or other sound dampening material between the hammer and the piling being driven.
 - (b) If currents are 1.7 miles per hour or less, surround the piling being driven by an unconfined bubble curtain that will distribute small air bubbles around 100% of the piling perimeter for the full depth of the water column.⁴
 - (c) If currents greater than 1.7 miles per hour, surround the piling being driven by a confined bubble curtain (*e.g.*, a bubble ring surrounded by a fabric or metal sleeve) that will distribute air bubbles around 100% of the piling perimeter for the full depth of the water column.
 - (d) Other sound attenuation devices as approved in writing by NOAA Fisheries.
- f. Heavy Equipment. Restrict use of heavy equipment as follows:
 - i. Choice of equipment. When heavy equipment will be used, the equipment selected will have the least adverse effects on the environment (*e.g.*, minimally-sized, low ground pressure equipment).
 - ii. Vehicle and material staging. Store construction materials, and fuel, operate, maintain and store vehicles as follows.
 - (1) To reduce the staging area and potential for contamination, ensure that only enough supplies and equipment to complete a specific job will be stored on-site.
 - (2) Complete vehicle staging, cleaning, maintenance, refueling, and fuel storage in a vehicle staging area placed 150 feet or more from any stream, waterbody or wetland, unless otherwise approved in writing by NOAA Fisheries.
 - (3) Inspect all vehicles operated within 150 feet of any stream, waterbody or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by Corps or NOAA Fisheries.
 - (4) Before operations begin and as often as necessary during operation, steam clean all equipment that will be used below

⁴ For guidance on how to deploy an effective, economical bubble curtain, see, Longmuir, C. and T. Lively, *Bubble Curtain Systems for Use During Marine Pile Driving*, Fraser River Pile and Dredge LTD, 1830 River Drive, New Westminster, British Columbia, V3M 2A8, Canada. Recommended components include a high volume air compressor that can supply more than 100 pounds per square inch at 150 cubic feet per minute to a distribution manifold with 1/16 inch diameter air release holes spaced every 3/4 inch along its length. An additional distribution manifold is needed for each 35 feet of water depth.

- bankfull elevation until all visible external oil, grease, mud, and other visible contaminants are removed.
- (5) Diaper all stationary power equipment (*e.g.*, generators, cranes, stationary drilling equipment) operated within 150 feet of any stream, waterbody or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream or waterbody.
- g. Site preparation. Conserve native materials for site restoration.
 - i. If possible, leave native materials where they are found.
 - ii. If materials are moved, damaged or destroyed, replace them with a functional equivalent during site restoration.
 - iii. Stockpile any large wood⁵, native vegetation, weed-free topsoil, and native channel material displaced by construction for use during site restoration.
2. To implement reasonable and prudent measure #2 (monitoring), the Corps shall:
- a. Implementation monitoring. Ensure that the applicant submits a monitoring report within 120 days of project completion describing the applicant's success meeting his or her permit conditions. The monitoring report will include the following information.
 - i. Project identification
 - (1) Applicant name, permit number, and project name.
 - (2) Type of activity.
 - (3) Project location, including any compensatory mitigation site(s), by 5th field HUC and by latitude and longitude as determined from the appropriate USGS 7-minute quadrangle map.
 - (4) Corps contact person.
 - (5) Starting and ending dates for work completed.
 - ii. Photo documentation. Photos of habitat conditions at the project and any compensation site(s), before, during, and after project completion.⁶
 - (1) Include general views and close-ups showing details of the project and project area, including pre and post construction.
 - (2) Label each photo with date, time, project name, photographer's name, and a comment about the subject.

⁵ For purposes of this Opinion only, 'large wood' means a tree, log, or rootwad big enough to dissipate stream energy associated with high flows, capture bedload, stabilize streambanks, influence channel characteristics, and otherwise support aquatic habitat function, given the slope and bankfull channel width of the stream in which the wood occurs. See, Oregon Department of Forestry and Oregon Department of Fish and Wildlife, *A Guide to Placing Large Wood in Streams*, May 1995 (www.odf.state.or.us/FP/RefLibrary/LargeWoodPlacemntGuide5-95.doc).

⁶ Relevant habitat conditions may include characteristics of channels, eroding and stable streambanks in the project area, riparian vegetation, water quality, flows at base, bankfull and over-bankfull stages, and other visually discernable environmental conditions at the project area, and upstream and downstream of the project.

- iii. Other data. Additional project-specific data, as appropriate for individual projects.
 - (1) Fish screen. Evidence of compliance with NOAA Fisheries' fish screen criteria.
 - (2) Pollution control. A summary of pollution and erosion control inspections, including any erosion control failure, contaminant release, and correction effort.
 - (3) Pilings.
 - (a) Number and type of pilings removed, including the number of pilings (if any) that broke during removal.
 - (b) Number, type, and diameter of any pilings installed (*e.g.*, untreated wood, treated wood, hollow steel).
 - (c) Description of how pilings were installed and any sound attenuation measures used..

3. MAGNUSON-STEVENSON ACT

3.1 Magnuson-Stevens Fishery Management and Conservation Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established procedures designed to identify, conserve, and enhance essential fish habitat (EFH) for those species regulated under a Federal fisheries management plan. Pursuant to the MSA:

- Federal agencies must consult with NOAA Fisheries on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH (§305(b)(2)).
- NOAA Fisheries must provide conservation recommendations for any Federal or state action that would adversely affect EFH (§305(b)(4)(A)).
- Federal agencies must provide a detailed response in writing to NOAA Fisheries within 30 days after receiving EFH conservation recommendations. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NOAA Fisheries EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations (§305(b)(4)(B)).

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA §3). For the purpose of interpreting this definition of EFH: “Waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated

biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR 600.10). Adverse effect means any impact which reduces quality and/or quantity of EFH, and may include direct (e.g., contamination or physical disruption), indirect (e.g. loss of prey or reduction in species fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

EFH consultation with NOAA Fisheries is required regarding any Federal agency action that may adversely affect EFH, including actions that occur outside EFH, such as certain upstream and upslope activities.

The objectives of this EFH consultation are to determine whether the proposed action would adversely affect designated EFH and to recommend conservation measures to avoid, minimize, or otherwise offset potential adverse effects to EFH.

3.2 Identification of EFH

Pursuant to the MSA, the Pacific Fisheries Management Council (PFMC) has designated EFH for federally-managed fisheries within the waters of Washington, Oregon, and California. Designated EFH for groundfish and coastal pelagic species encompasses all waters from the mean high water line, and upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon and California, seaward to the boundary of the U.S. exclusive economic zone (370.4 km) (PFMC 1998a, 1998b). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other waterbodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable artificial barriers (as identified by the PFMC 1999), and longstanding, naturally-impassable barriers (*i.e.* natural waterfalls in existence for several hundred years) (PFMC 1999). In estuarine and marine areas, designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception to the Canadian border (PFMC 1999).

Detailed descriptions and identifications of EFH are contained in the fishery management plans for groundfish (PFMC 1998a), coastal pelagic species (PFMC 1998b), and Pacific salmon (PFMC 1999). Casillas *et al.* (1998) provides additional detail on the groundfish EFH habitat complexes. Assessment of the potential adverse effects to these species' EFH from the proposed action is based, in part, on these descriptions and on information provided by the Corps.

3.3 Proposed Action

The proposed action is detailed above in section 1.2 of this document. For the purposes of this EFH consultation, the action area is defined as the streambed, streambank and riparian corridor of the Willamette River, extending to the upstream project disturbance limits and downstream

one mile below the project disturbance limits. This area has been designated as EFH for various life stages of chinook salmon and coho salmon.

3.4 Effects of Proposed Action

As described in detail in section 2.1.3 of this document, the proposed activities may result in short-term adverse effects to water quality (sediment, chemical contamination). NOAA Fisheries expects short-term adverse effects from increases in turbidity and the potential for chemical contamination within the action area.

3.5 Conclusion

The proposed action will adversely affect the EFH for chinook and coho salmon.

3.6 EFH Conservation Recommendations

Pursuant to section 305(b)(4)(A) of the MSA, NOAA Fisheries is required to provide EFH conservation recommendations for any Federal or state agency action that would adversely affect EFH. The conservation measures proposed for the project by the Corps, all of the reasonable and prudent measures and the terms and conditions contained in sections 2.2.2 and 2.2.3 are applicable to salmon EFH. Therefore, NOAA Fisheries incorporates each of those measures here as EFH conservation recommendations.

3.7 Statutory Response Requirement

Please note that the MSA (section 305(b)) and 50 CFR 600.920(j) requires the Federal agency to provide a written response to NOAA Fisheries after receiving EFH conservation recommendations within 30 days of its receipt of this letter. This response must include a description of measures proposed by the agency to avoid, minimize, mitigate or offset the adverse impacts of the activity on EFH. If the response is inconsistent with a conservation recommendation from NOAA Fisheries, the agency must explain its reasons for not following the recommendation.

3.8 Supplemental Consultation

The Corps must reinitiate EFH consultation with NOAA Fisheries if either action is substantially revised or new information becomes available that affects the basis for NOAA Fisheries' EFH conservation recommendations (50 CFR 600.920).

4. LITERATURE CITED

- Abbott, R. and E. Bing-Sawyer. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Othodon microlepidotus*). Draft report prepared for Caltrans District 4. October 10, 2002.
- Ainley, D.G. 1984. Cormorants Family Phalacrocoracidae. Pages 92- 101 in D. Haley ed. Seabirds of the eastern North Pacific and Arctic waters. Pacific Search Press, Seattle. 214 p.
- Beamesderfer, R.C. and B.E. Rieman. 1991. Abundance and Distribution of Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447.
- Bell, M.C. 1991. Fisheries handbook of Engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers. North Pacific Division.
- Bevelhimer, M.S. 1996. Relative importance of temperature, food, and physical structure to habitat choice by smallmouth bass in laboratory experiments. Trans. Am. Fish. Soc. 125:274-283.
- Blackwell, B.F., W.B. Krohn, N.R. Dube and A.J. Godin. 1997. Spring prey use by double-crested cormorants on the Penobscot River, Maine, USA. Colonial Waterbirds 20(1):77-86.
- Caltrans. 2001. Fisheries Impact Assessment, Pile Installation Demonstration Project for the San Francisco - Oakland Bay Bridge, East Span Seismic Safety Project, August 2001. 9 pp.
- Carlson, T., G. Ploskey, R. L. Johnson, R. P. Mueller and M. A. Weiland. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Review draft report to the Portland District Corps of Engineers prepared by Pacific Northwest National Laboratory, Richland, Washington. 35 p.
- Casillas, E., L. Crockett, Y. deReynier, J. Glock, M. Helvey, B. Meyer, C. Schmitt, M. Yoklavich, A. Bailey, B. Chao, B. Johnson, and T. Pepperell,. 1988. Essential Fish Habitat West Coast Groundfish Appendix. National Marine Fisheries Service. Seattle, Washington. 778 p.
- City of Portland, Bureau of Environmental Services. Website accessed October 2001
http://www.cleanrivers-pdx.org/clean_rivers/ws_willamette.htm

- Colle, D.E., R.L. Cailteux, and J.V. Shireman. 1989. Distribution of Florida largemouth bass in a lake after elimination of all submersed aquatic vegetation. *N. Am. Journal of Fish. Mgmt.* 9:213-218.
- Collis, K., R.E. Beaty and B.R. Crain. 1995. Changes in Catch Rate and Diet of Northern Squawfish Associated With the Release of Hatchery-Reared Juvenile Salmonids in a Columbia River Reservoir. *North American Journal of Fisheries Management* 15:346-357.
- Derby, C.E. and J.R. Lovvorn. 1997. Predation on fish by cormorants and pelicans in a cold-water river: a field and modeling study. *Can. J. Fish. Aquat. Soc.* 54:1480-1493.
- Dolat, S.W. 1997. Acoustic measurements during the Baldwin Bridge demolition (final, dated March 14, 1997). Prepared for White Oak Construction by Sonalysts, Inc, Waterford, CT.. 34 p. + appendices. Enger et al. 1992.
- Duffy, D.C. 1995. Why is the double-crested cormorant a problem? Insights from cormorant ecology and human sociology. Pages 25-32 in *The Double-crested Cormorant: biology, conservation and management* (D.N. Nettleship and D.C. Duffy, eds.) *Colonial Waterbirds* 18 (Special Publication 1).
- Enger, P.S., H.E. Karlsen, F.R. Knudsen, and O. Sand. 1993. Detection and reaction of fish to infrasound. *Fish Behaviour in Relation to Fishing Operations.*, 1993, pp. 108-112, ICES marine science symposia. Copenhagen vol. 196.
- Gerking, S.D. 1994. *Feeding Ecology of Fish.* Academic Press Inc., San Diego, CA. 416 p.
- Harrison, C.S. 1984. Terns Family Laridae Pages 146-160 in D. Haley, D. ed. *Seabirds of eastern North Pacific and Arctic waters.* Pacific Search Press. Seattle. 214 p.
- Harrison, P. 1983. *Seabirds: an Identification Guide.* Houghton Mifflin Company. Boston. 448 pp.
- Helfman, G.S. 1981. The advantage to fishes of hovering in shade. *Copeia.* 1981(2):392-400.
- Hobson, E. S. 1979. Interactions between piscivorous fishes and their prey. Pages 231-242 in R.H. Stroud and H. Clepper, editors. *Predator-prey systems in fisheries management.* Sport Fishing Institute, Washington D.C.
- Howick, G. L. and W.J. O'Brien. 1983. Piscivorous feeding behavior of largemouth bass: an experimental analysis. *Trans. Am. Fish. Soc.* 112:508-516.

- Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. *Journal of Fish Biology*, 51:824-829.
- Krohn, W.B., R.B. Allen, J.R. Moring and A.E. Hutchinson. 1995. Double-crested cormorants in New England; population and management histories. Pages 99-109 in *The Double-crested Cormorant: biology, conservation and management* (D.N. Nettleship and D.C. Duffy, eds.) *Colonial Waterbirds* 18 (Special Publication 1).
- Longmuir, C., and T. Lively. 2001. Bubble curtain systems for use during marine pile driving. Report by Fraser River Pile & Dredge Ltd., New Westminster, British Columbia. 9 pp.
- Mesing, C.L. and A.M. Wicker. 1986. Home range, spawning migrations, and homing of radio-tagged Florida largemouth bass in two central Florida lakes. *Trans. Am. Fish. Soc.* 115:286-295.
- Mueller, G. 1980. Effects of recreational river traffic on nest defense by longear sunfish. *Trans. Am. Fish. Soc.* 109: 248-251.
- Nedwell, J., and B. Edwards. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Report by Subacoustech, Ltd to David Wilson Homes, Ltd.
- Petersen, J.M. and D.M. Gadomski. 1994. Light-Mediated Predation by Northern Squawfish on Juvenile Chinook Salmon. *Journal of Fish Biology* 45 (supplement A), 227-242.
- Petersen, C.J., D.B. Jepsen, R.D. Nelle, R.S. Shively, R.A. Tabor, T.P. Poe. 1990. System-Wide Significance of Predation on Juvenile Salmonids in Columbia and Snake River Reservoirs. Annual Report of Research. Bonneville Power Administration Contract DE-AI79-90BP07096. Project No. 90-078. 53 pp.
- Pflug, D.E. and G.B. Pauley. 1984. Biology of Smallmouth Bass (*Micropterus dolomieu*) in Lake Sammamish, Washington. *Northwest Science* 58(2):119-130.
- PFMC (Pacific Fishery Management Council), 1998a. Final Environmental Assessment/Regulatory Review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan. October 1998.
- PFMC (Pacific Fishery Management Council), 1998b. The Coastal Pelagic Species Fishery Management Plan: Amendment 8. Portland, Oregon.

- PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat, Adverse Impacts and Recommended Conservation Measures for Salmon. Portland, Oregon.
- Phillips, S.H. 1990. A guide to the construction of freshwater artificial reefs. Sportfishing Institute. Washington D.C. 24 pp.
- Poe, T.P, H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of Predaceous Fishes on Out-Migrating Juvenile Salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.
- Raibley, P.T., K.S. Irons, T.M. O'Hara, and K.D. Blodgett. 1997. Winter habitats used by largemouth bass in the Illinois River, a large river-floodplain ecosystem. N. Am. J. Fish. Mgmt. 17:401-412.
- Reyff, J.A. 2003. Underwater sound levels associated with seismic retrofit construction of the Richmond-San Rafael Bridge. Document in support of Biological Assessment for the Richmond-San Rafael Bridge Seismic Safety Project. January, 31, 2003. 18 pp.
- Rieman, B.E. and R.C. Beamesderfer. 1991. Estimated Loss of Juvenile Salmonids to Predation by Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.
- Rogers, P.H. and M. Cox. 1988. Underwater sound as a biological stimulus. pp. 131-149 *in*: Sensory biology of aquatic animals. Atema, J, R.R. Fay, A.N. Popper and W.N. Tavolga (eds.). Springer-Verlag. New York.
- Sand, O., P.S. Enger, H.E. Karlsen, F. Knudsen, T. Kvernstuen. 2000. Avoidance responses to infrasound in downstream migrating European silver eels, *Anguilla anguilla*. Environmental Biology of Fishes, 57:327-336.
- Stotz, T. and J. Colby. 2001. January 2001 dive report for Mukilteo wingwall replacement project. Washington State Ferries Memorandum. 5 pp. + appendices.
- Walters, D.A., W.E. Lynch, Jr., and D.L. Johnson. 1991. How depth and interstice size of artificial structures influence fish attraction. N. Am. J. Fish. Mgmt. 11:319-329.
- Wanjala, B.S., J.C. Tash, W.J. Matter and C.D. Ziebell. 1986. Food and habitat use by different sizes of largemouth bass (*Micropterus salmoides*) in Alamo Lake, Arizona. Journal of Freshwater Ecology Vol. 3(3):359-368.

- Ward, D.L. and A.A. Nigro. 1992. Differences in Fish Assemblages Among Habitats Found in the Lower Willamette River, Oregon: Application of and Problems With Multivariate Analysis. *Fisheries Research* 13:119-132.
- Ward, D.L., A.A. Nigro, R.A. Farr, and C.J. Knutsen. 1994. Influence of Waterway Development on Migrational Characteristics of Juvenile Salmonids in the Lower Willamette River, Oregon. *North American Journal of Fisheries Management* 14:362-371.
- Warrington, P. D. 1999a. Impacts of recreational boating on the aquatic environment. <http://www.nalms.org/bclss/impactsrecreationboat.htm>
- Warrington, P.D1999b. Impacts of outboard motors on the aquatic environment. <http://www.nalms.org/bclss/impactsoutboard.htm>
- Willamette Restoration Initiative (WRI). 1999. Restoring the Willamette Basin: Issues and Challenges. Prepared by Institute for the Northwest. Report accessed at: http://www.oregonwri.org/basin_restore/rest_will_basin2a.pdf
- Würsig, B., C.R. Greene, Jr., and T.A. Jefferson. 2000. Development of an air bubble curtain to reduce underwater noise from percussive piling. *Marine Environmental Research* 49: 19-93.